Appendix 5-C
Examples of Applying Ecology's Landscape Analysis

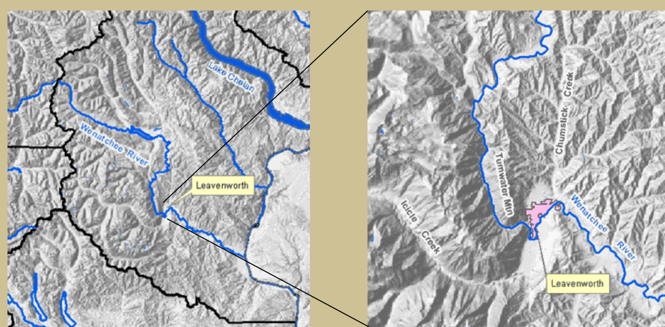
The following pages present examples of how Ecology's landscape analysis can be applied in local jurisdictions in Washington. Examples are provided for two local jurisdictions: the City of Leavenworth and Whatcom County.

City of Leavenworth

Landscape Analysis at the Sub-basin Scale

Based on
Leavenworth Water Problem Study of 1999

Additional input from Matt Karrer, Hydrologist, US Forest Service



WASHINGTON STATE DEPARTMENT OF ECOLOGY

Approach

Step 1 - Identify regional problems

Step 2 - Determine water flow processes

- Topography to draw sub-basins
- Determine initial water flow patterns
- Use geologic info & soils to refine flow patterns
- Draw profile & finalize flow patterns

Step 3 - Summarize natural water flow processes

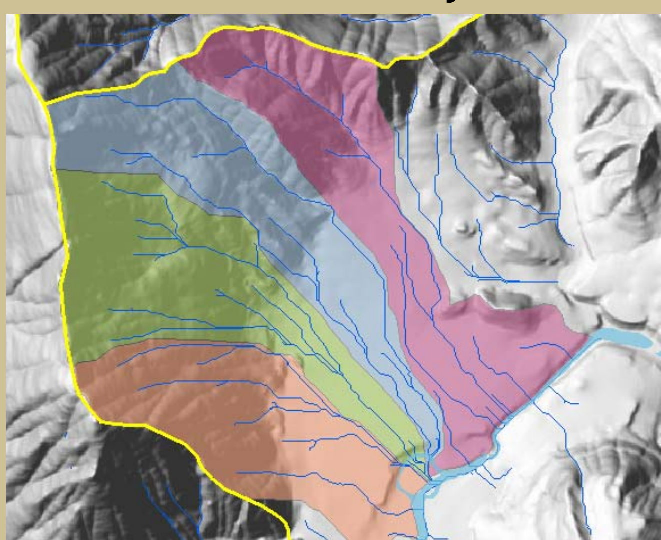
Step 4 - Identify areas where land use alters natural conditions

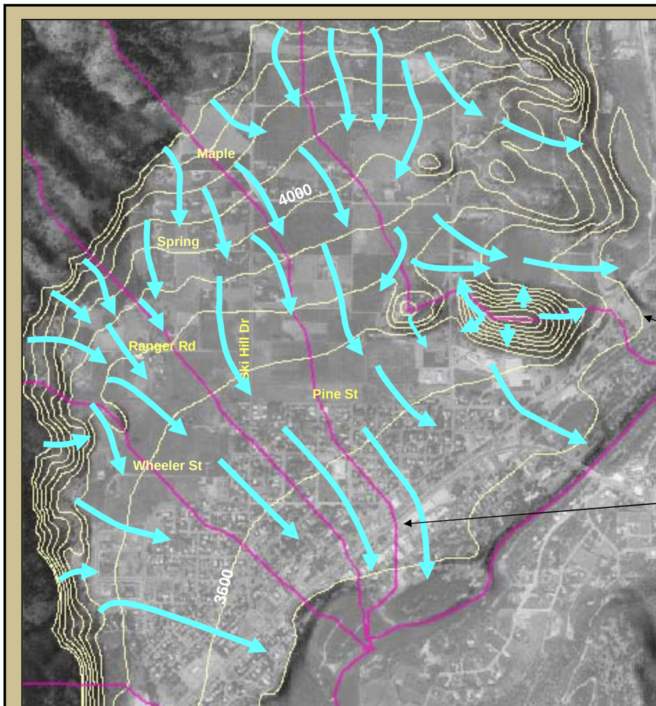
Step 5 - Identify restoration opportunities

Step 1 - Identify regional problem

- ✓ Flooding
- ✓ Water quality
- Downstream Erosion
- ✓ Loss of historic habitat
- ✓ Loss of habitat connectivity

Identify Sub-basins Contributing to Study Area

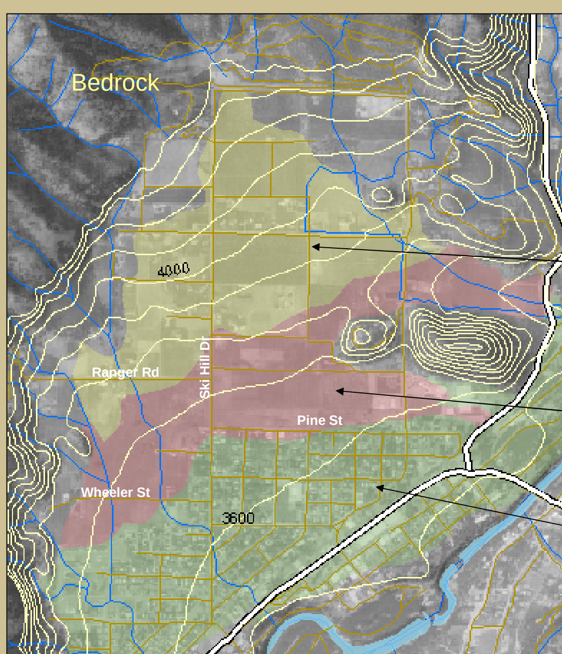




General Direction of Shallow Ground-water Flow

Contour lines – 100 ft

Subbasins



Collect Geologic Information:

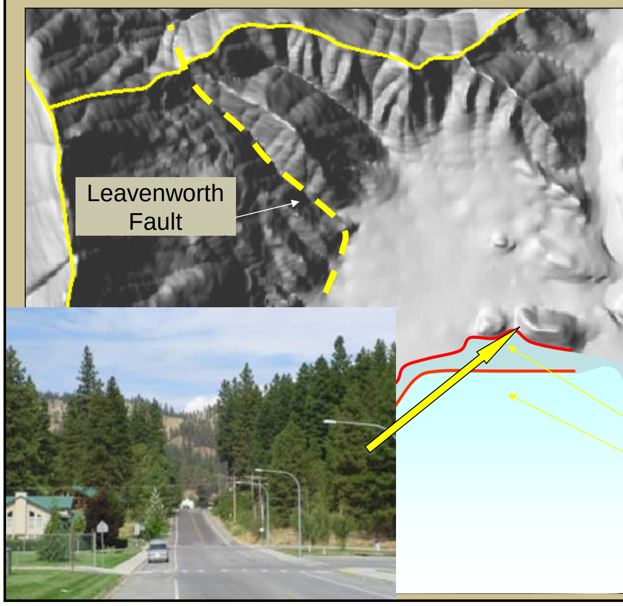
Surficial Geology

Older Alluvium – courser material

Older Alluvium – finer material

Till

Collect Geologic Information: Identify Faults and Glaciation Pattern



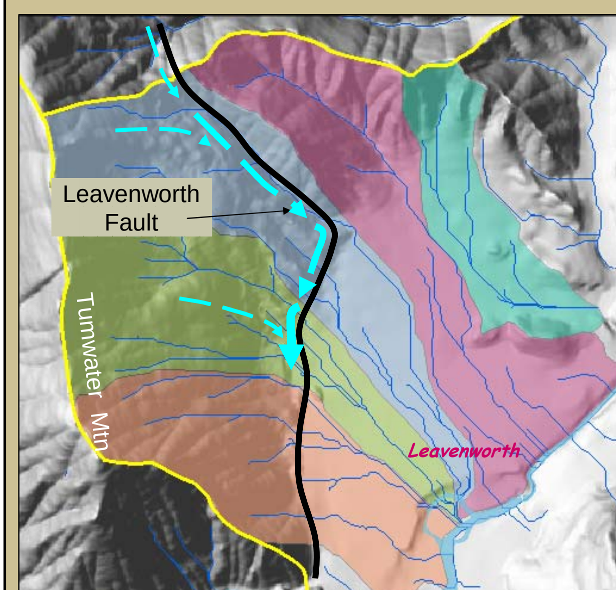
Leavenworth Fault – represents a major shear zone

Glaciers advanced several times from the south into the Ski Hill area and then receded.

Each time they receded they left terminal moraines.

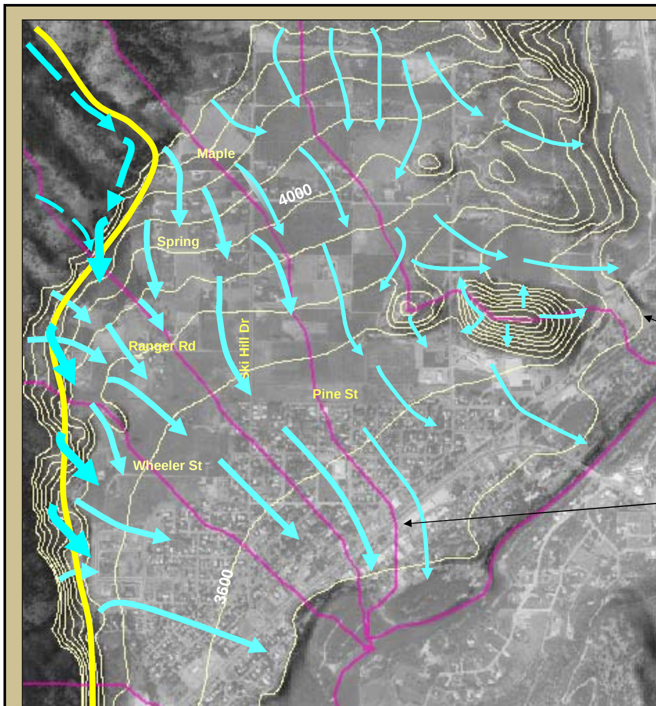
General Location of Moraines

Groundwater Movement Affected by the Fault



The fault shear zone creates a path of lower resistance for groundwater flow, so groundwater moving down-gradient will tend to follow the fault line.

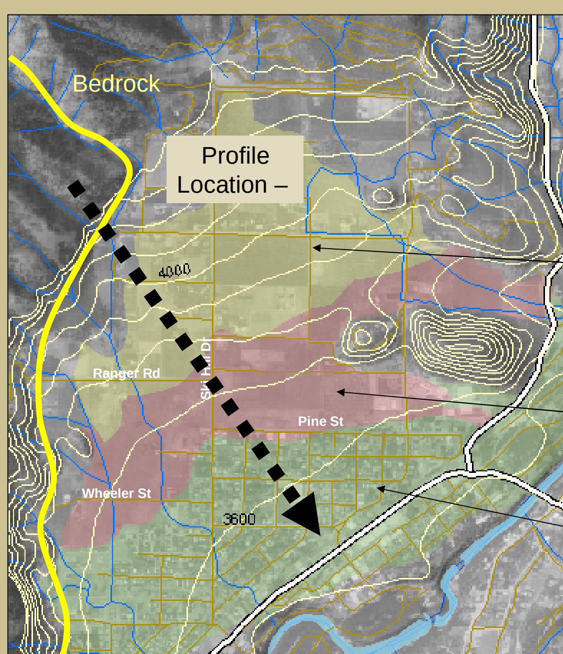
This results in the lower basins receiving water contributed from upper basins, greatly increasing the quantity of water being delivered.



Refine Shallow Ground-water Flow

Contour lines – 100 ft

Subbasins



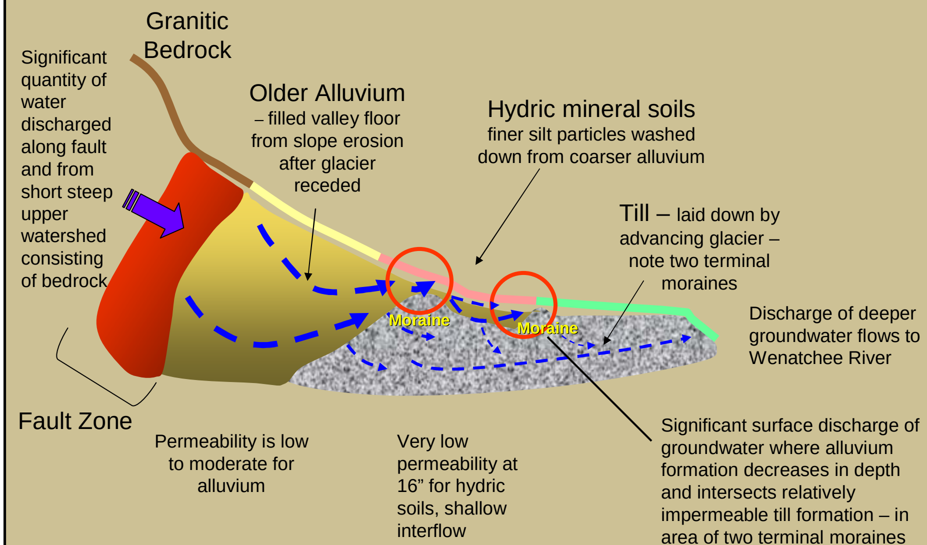
Locate Profile through Landforms

Older Alluvium – courser material

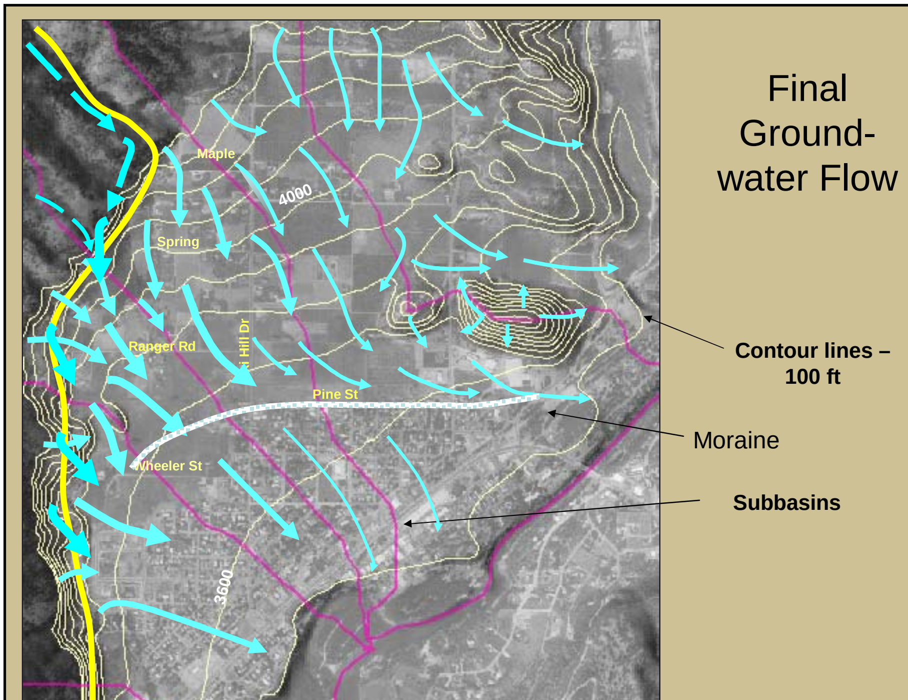
Older Alluvium – finer material

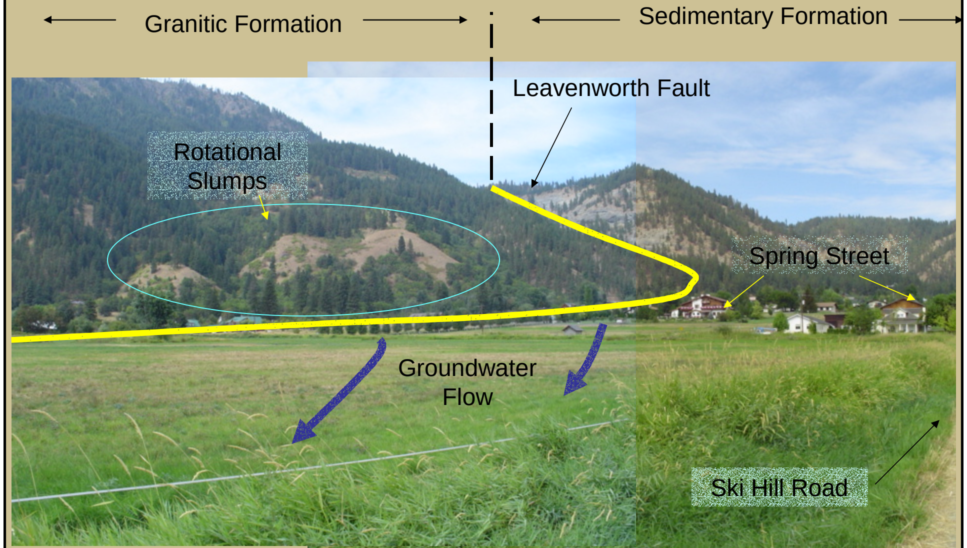
Till

Profile Diagram



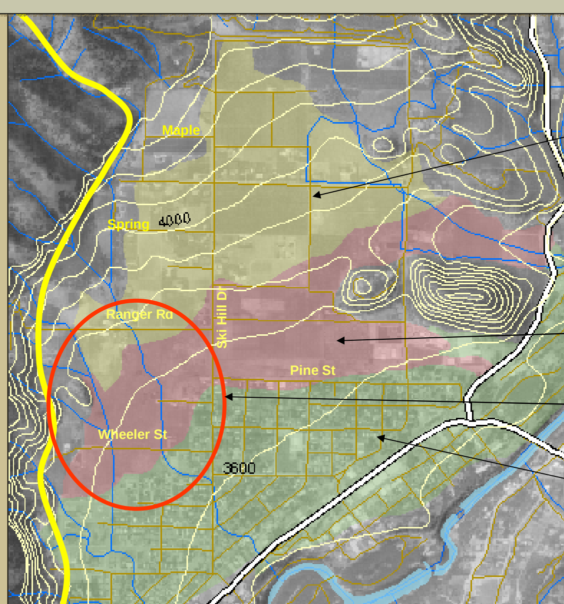
Final Ground-water Flow





View Northwest from Ski Hill Road Towards Tumwater Mnt.

Step 3 - Summarize Natural Water Flow Processes



Older Alluvium :

Area of recharge – provides storage of water and removal of nutrients and pathogens

Hydric:

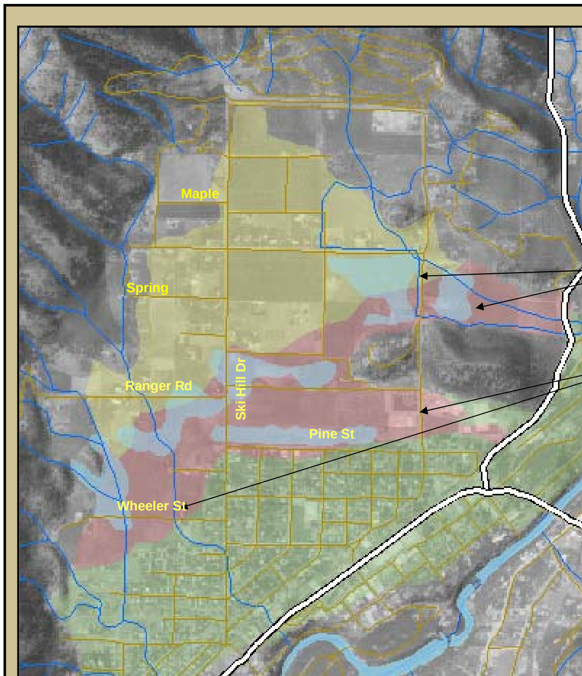
Area of discharge – wetland habitat; also provides water quality functions and some limited water storage

Quantity of groundwater discharged in western portion appears to be greater due to fault

Till:

Area of limited recharge and deeper groundwater movement

Step 4 – Identify areas where land use (existing/proposed) alters natural conditions



Indicators of Alteration to Water Flow Processes: Extent of Wetlands

Existing Wetlands

VS

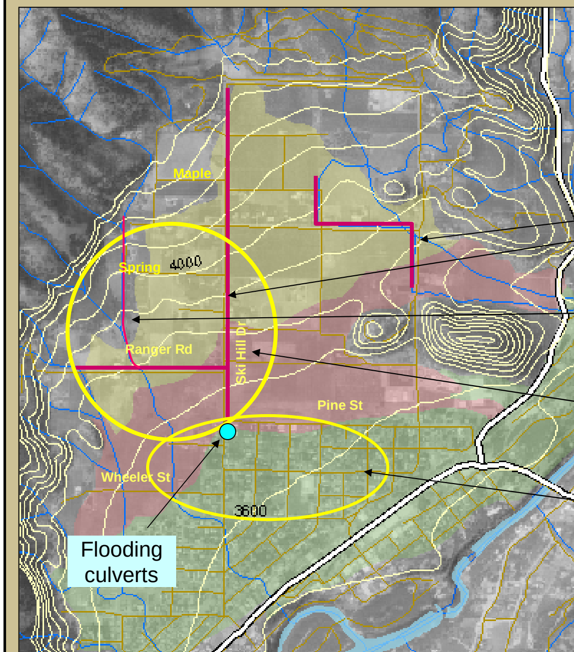
Historic or Potential Wetlands

Wetlands historically extended to the edge of the pink polygon which are **hydric soils** - soils that only form under saturated conditions.

This indicates that subsurface and surface flow to this area has been altered.

Indicators of Alteration to Water Flow Processes:

Ditch/culvert network and areas of flooding/wetness



Major Ditching

Ski Hill Rd. blocks some groundwater and surface flows

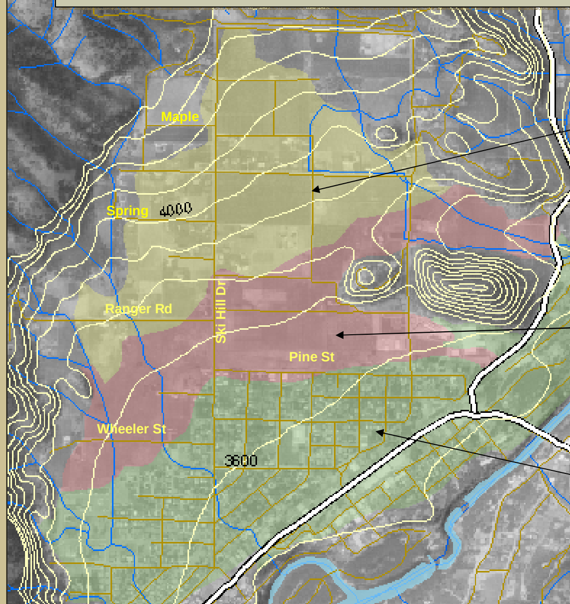
Channelization of Streams

Area of reported increased subsurface wetness

Area of flooding and sheet flow

Northeast Corner of Intersection of Pine and Ski Hill Road

Summary of Alteration to Water Flow Processes

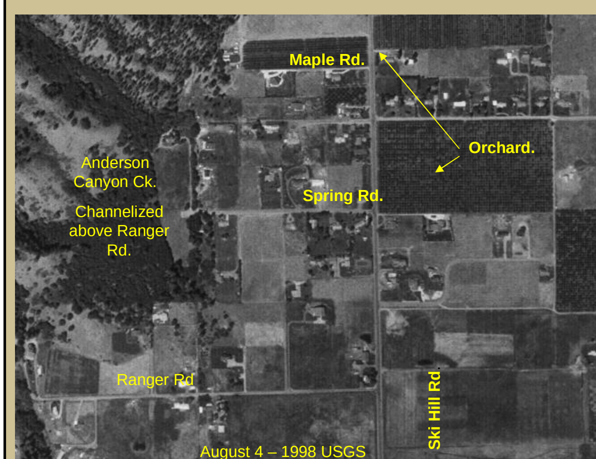


Older Alluvium : Ditching, especially along Ski Hill Rd., has significantly reduced subsurface flow of water thereby increasing flooding downstream

Hydric: Surface and subsurface flows have been reduced significantly in eastern portion. Western portion is reportedly wetter.

Till: Sheet flow and flooding has increased due to rapid delivery of upslope flows through ditches.

Summary of Alteration to Water Flow Processes - continued



Western Portion of Study Area

"Increased" subsurface wetness south of Maple Rd. and West of Ski Hill Rd appears to be due to a wetter climatic cycle since drought period of the early 90's and not land use change.

Land use alteration typically causes surface flooding not year round shallow groundwater flows as has been reported.

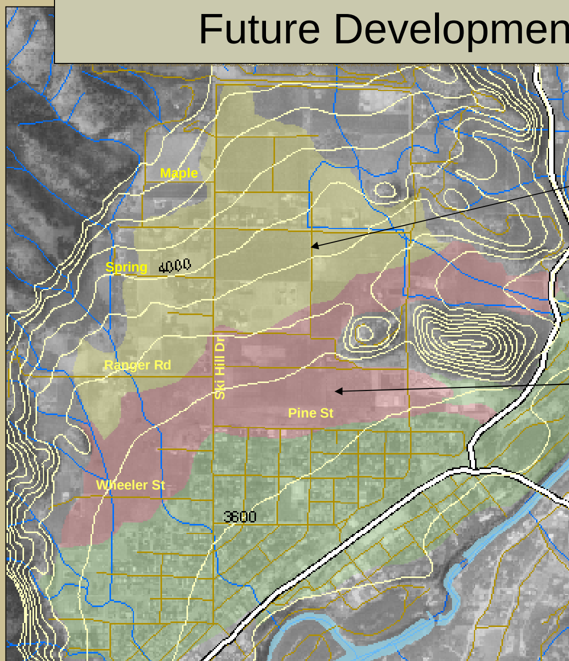
Preliminary Conclusions Based on Review & Analysis of Water Flow Alterations

- The Ski Hill area has historically been a very wet area due to a combination of geology, slope, and faulting.
- Initial analysis indicates that the bedrock area draining to the Leavenworth Fault is the primary source of groundwater in Ski Hill
- Water processes in the bedrock area have not been significantly altered (i.e., natural conditions exist).
- The lower, smaller area of the basin (Ski Hill area) has little influence on the quantity of groundwater flow present.
  - The increasing wetness is probably due to climatic changes in the past decade. (Since drought of '92 rainfall has increased)

Preliminary Conclusions Based on Review & Analysis of Water Flow Alterations….

- Groundwater is forced to the surface by two terminal moraines at the southern extent of the alluvial formation
- The surface water problems in Ski Hill :
  - Appear to be exacerbated by ditching, curtain drains, and below grade structures which intercept groundwater flow and convert to surface flow, accelerating delivery of that water to lower portion of the Ski Hill area.
  - Additional development in this area, without a comprehensive restoration plan and low impact development standards, would significantly increase the flooding and water quality problems

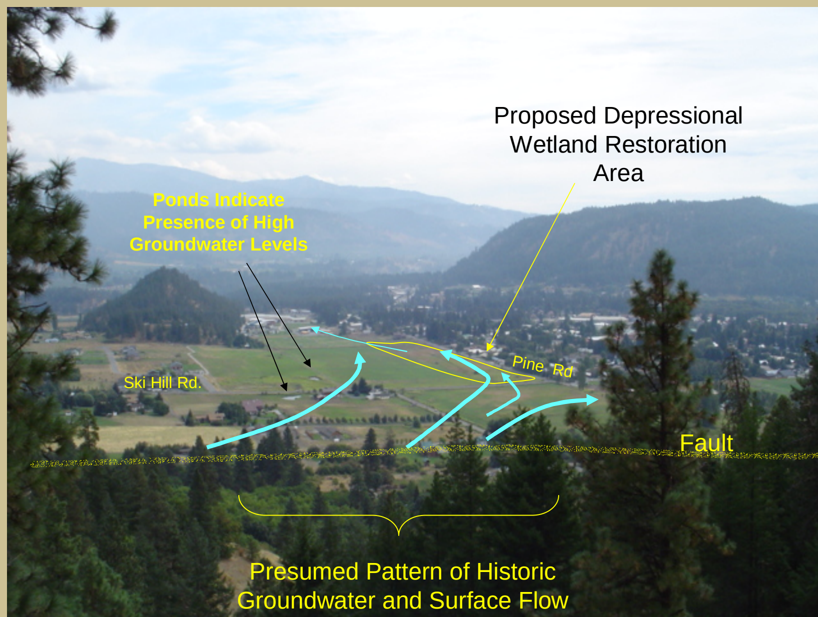
Future Development Conflicts



Future residential development can reduce recharge and **increase flooding down gradient by converting groundwater flow to surface flow** (ditching, curtain drains, basements, impermeable surface)

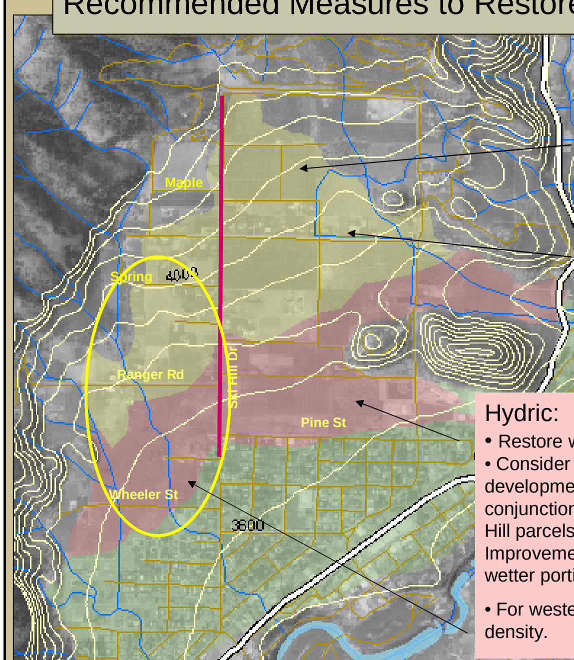
Future residential development will impact existing and potential wetland habitat, and water quality and water quantity functions will be degraded. **Development will further exacerbate flooding problems**.

Step 5 – Identify restoration opportunities



View of Proposed Restoration Area (Looking Southeast From Tumwater Mtn.)

Recommended Measures to Restore Water Flow Processes



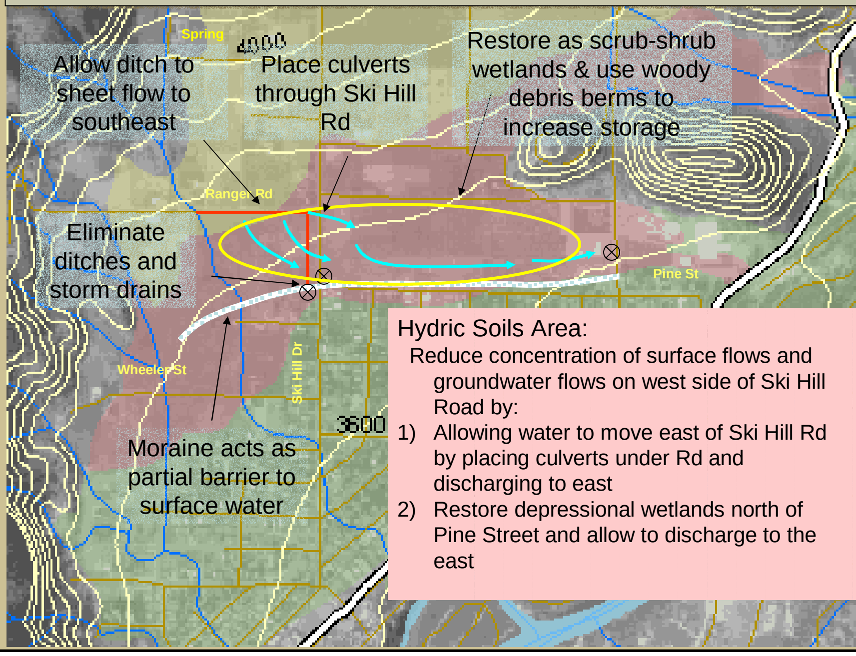
Older Alluvium :

- Eliminate ditching & develop measures to facilitate recharge of surface flows into alluvium (See C St. Design in Seattle):
- Eliminate or redesign features (i.e. basements, french and curtain drains, ditching) in new construction that interrupt groundwater flow and create surface flow (See above).
- Deep till or rip soils and plant areas with native shrubs and trees. Soil has developed shallow compacted layer due to farming.

Hydric:

- Restore wetlands in wetter areas
- Consider protective measures such as transfer of development rights or conservation easements in conjunction with a system of in lieu fees on other Ski Hill parcels not affected (e.g. form a Local Improvement District) to compensate land owners in wetter portions.
- For western portion consider lower development density.

Recommended Measures to Restore Water Flow Processes



Results Since Presentation of This Study to City of Leavenworth

- City **submitted a grant proposal** to Department of Community, Trade, & Economic Development to prepare a “green infrastructure” plan for the Ski Hill area.
- City **was awarded the grant**
- City is **reviewing three proposals** for a “green infrastructure” plan
- Plan completion expected by winter 2004

Analysis and Characterization of Functions and Ecosystem-wide Processes for SMP Update

Whatcom County

July 28, 2004

1

Why Analyze & Characterize Ecosystem Wide Processes?

- Required by the new shoreline guidelines
- Provides a framework for developing the shoreline plan
- Identifies important ecosystem relationships within the County
  - Identifies areas sensitive to changes from land use
  - Identifies areas for protection or restoration of resources
  - Identifies areas where restoration can correct current problems

2

Characterization of Functions & Processes Requires Application of the Following Steps (WAC Section 173-26-201(3)d)i)

1. Identify & assess ecosystem-wide processes and ecological functions and determine their relationship.
2. Identify ecological functions and ecosystem-wide processes that are healthy, altered, impacted, and missing.
3. Identify measures to protect and restore ecosystem-wide processes and ecological functions.

3

Executive Summary
Identify Objectives – Dakota Sub-basin

Relevant Process & or Function – Unaltered Conditions	Existing or Potential Environmental Issue	Altered Functions and Processes	Protection & Restoration Objectives	Protection – Mechanism & Measures	Restoration Mechanism
Low summer baseflow Recharge function is low to moderate over large area of watershed	Potential: Reduced diversity of aquatic organism. Increased mortality of smolts.	Recharge function is reduced in areas of drained depressional wetlands and tilled soils	Maximize recharge	Increase infiltration: Retain forest cover Protect depressional wetlands in upper watershed Minimize impervious cover	Restore native cover and wetlands in areas of highest recharge function
Reduced tidal flushing Water quality function is high for most of the watershed except for confining units on steep slopes	Existing: Water quality impacts. Closure of Drayton harbor shellfish beds. Reports of harmful algal blooms. Cause – fecal coliform and nutrients	Water quality function is reduced in areas of drained wetlands, tilled soils, and cleared forest /shrub cover	Maximize residence time	Protect existing depressional wetlands & forest cover	Restore wetlands below areas with highest degree of alteration Restore forest/shrub cover

4

Organizing Your Approach to the Characterization and Analysis

- What existing information is helpful?
  - Quantitative studies
  - Qualitative descriptions
  - Different scales
  - Different geographic extents
  - (Too much info)
- Identify information that helps develop the analysis

5

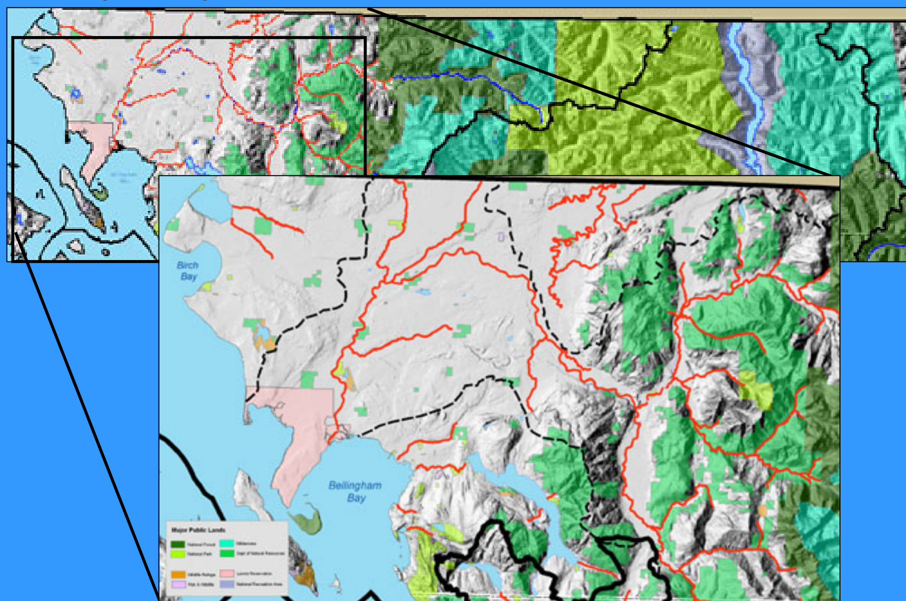
Step 1. Identify and assess ecosystem-wide processes & ecological functions and determine their relationship

- Collect base information for analysis area
- Describe ecosystem-wide processes at the landscape scale
- Describe the functions for the landscape scale-
- Describe ecosystem-wide processes at the sub-basin scale
- Describe the functions at the sub-basin scale-
- Analyze and describe relationship of processes to functions in the shoreline

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

6

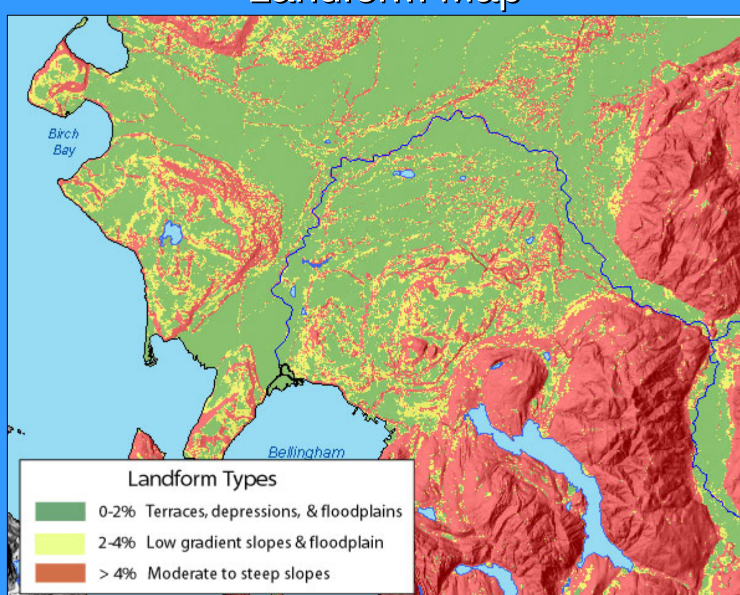
Identify analysis area…..then collect base information…



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

7

Landform Map

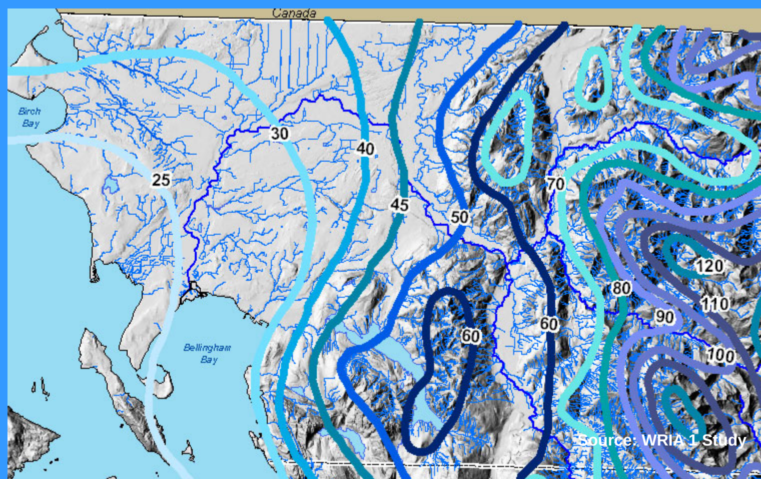


Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

8

Precipitation Patterns

Precipitation gradient indicates areas of relative difference in quantity of runoff



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

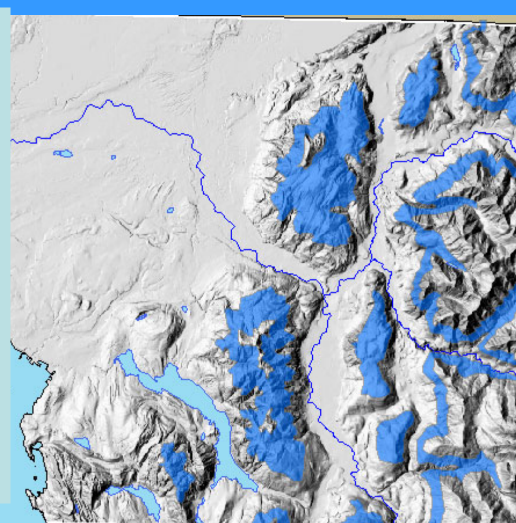
9

Rain-on-Snow Zones

Rain-on snow areas significantly affect the timing and magnitude of runoff events.

Runoff during rain-on-snow events has been associated with mass-wasting of hillslopes, damage to riparian zones, and downstream flooding.

The location and extent of these zones can help identify downstream areas that may have runoff hydrographs that are affected by these events.

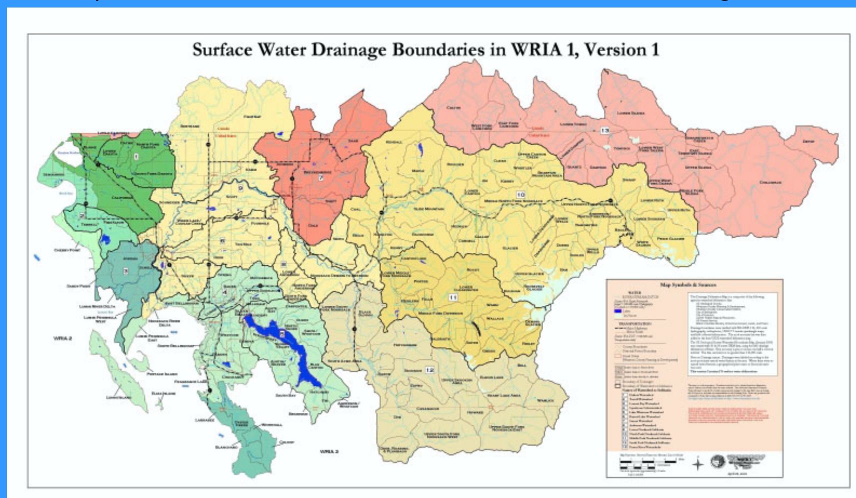


Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

10

Surface Water Drainage Patterns & Sub-basins

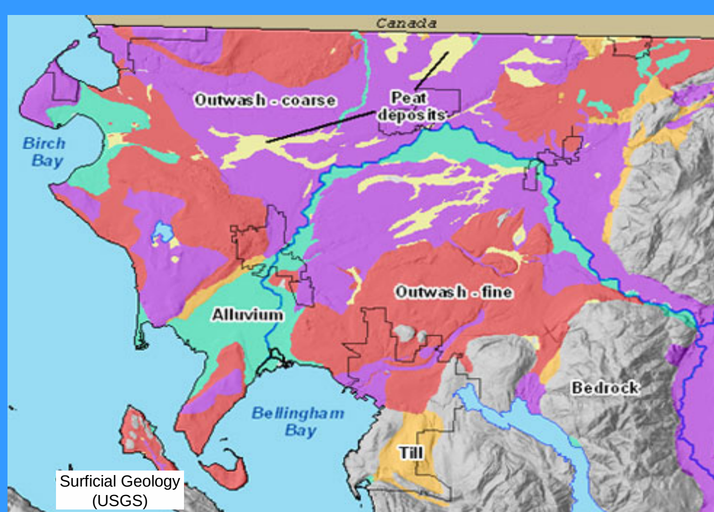
- delineate surface water network
- depending on scale, don't always coincide exactly with groundwater flow
- important to understand the links between surface water and groundwater



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

11

Surficial Geology



Surficial Geology (USGS)

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

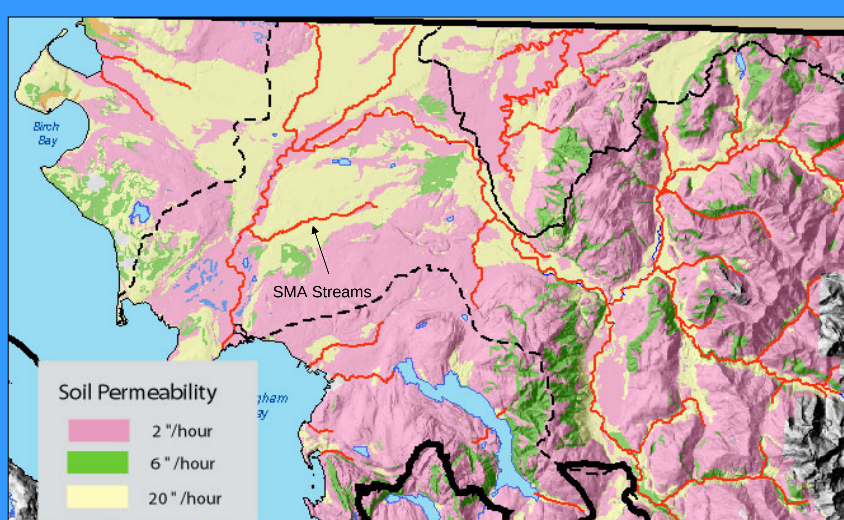
12

Geologic Hazards

- Map of landslides, alluvial fans, etc???

13

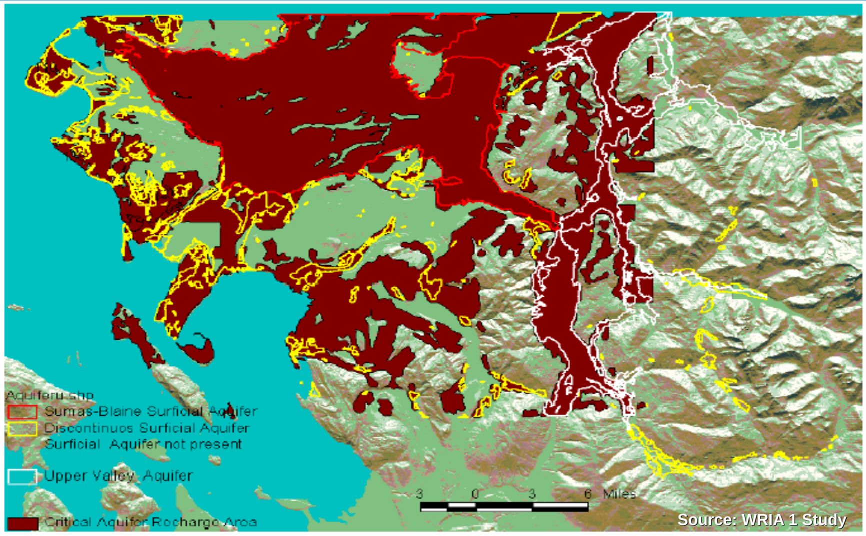
Soil Permeability



14

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

Critical Recharge Areas



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

15

Aquifer Storage Capacity

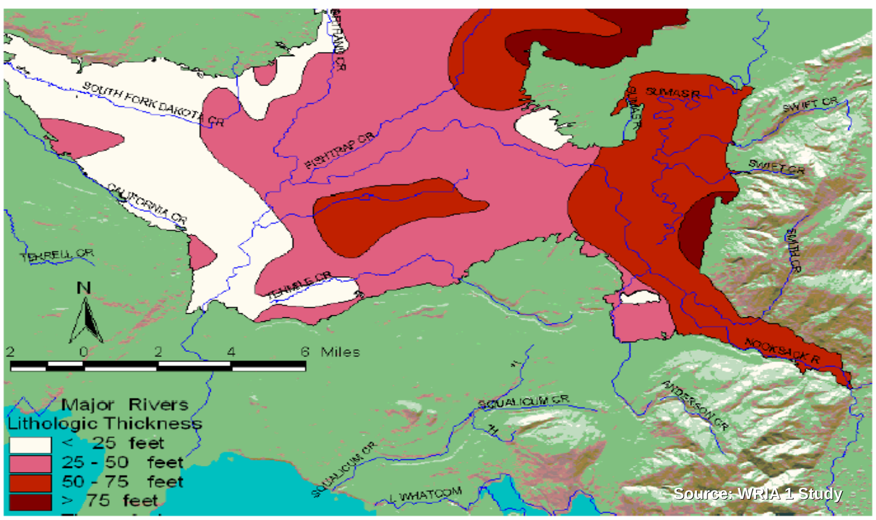
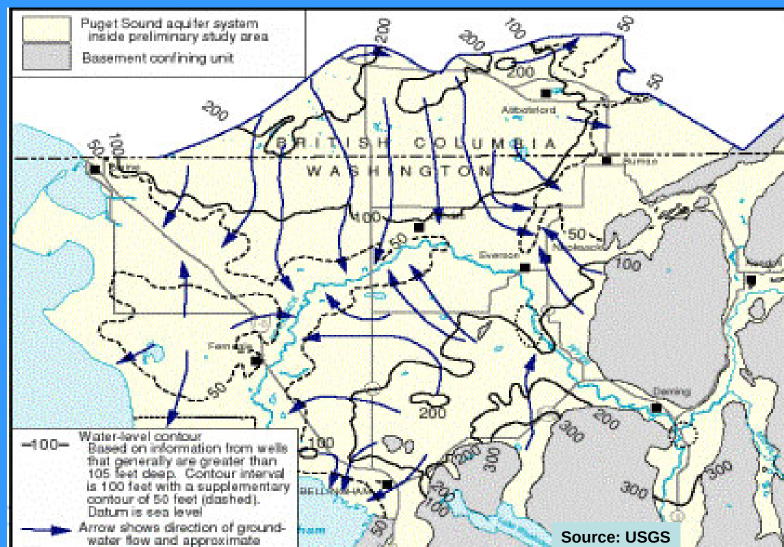


Figure 1.2.3 Aquifer thickness of central/ lowlands of the Nooksack

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

16

Groundwater Flow Lines



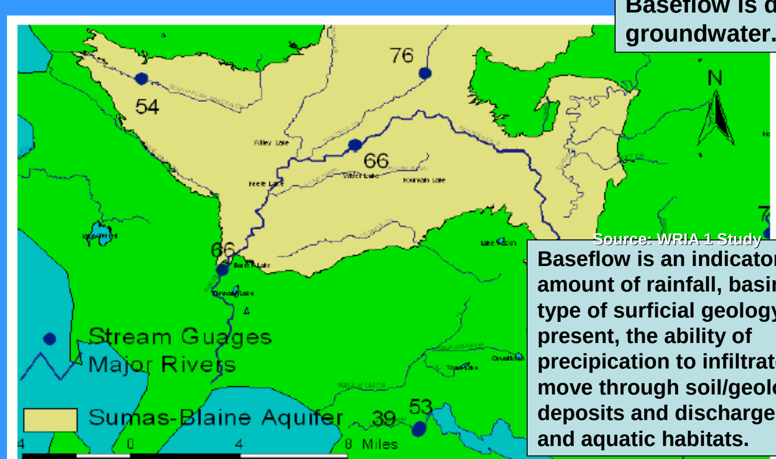
Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

17

Baseflow Contribution to Mean Annual Stream Flow

Measured As Percent of Annual Flow

Baseflow is driven by groundwater.



Baseflow is an indicator of the amount of rainfall, basin size, the type of surficial geology and soil present, the ability of precipitation to infiltrate and move through soil/geologic deposits and discharge to creeks and aquatic habitats.

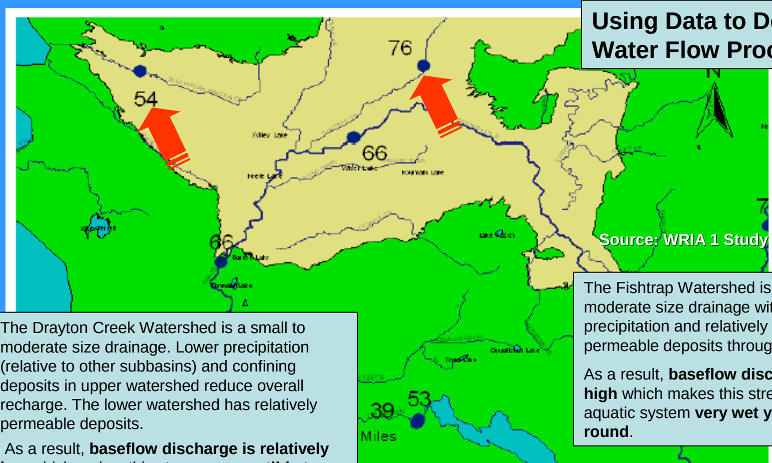
Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

18

Baseflow Contribution to Mean Annual Stream Flow

Measured As Percent of Annual Flow

Using Data to Describe Water Flow Processes



The Drayton Creek Watershed is a small to moderate size drainage. Lower precipitation (relative to other subbasins) and confining deposits in upper watershed reduce overall recharge. The lower watershed has relatively permeable deposits.

As a result, **baseflow discharge is relatively low** which makes this stream **susceptible to low flows** in the summer months

The Fishtrap Watershed is a moderate size drainage with high precipitation and relatively permeable deposits throughout.

As a result, **baseflow discharge is high** which makes this stream and aquatic system **very wet year round**.

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

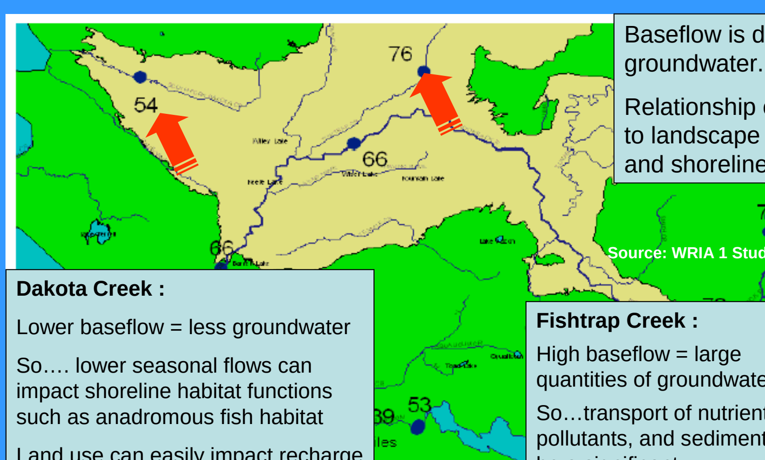
19

Baseflow Contribution to Mean Annual Stream Flow

Measured As Percent of Annual Flow

Baseflow is driven by groundwater.

Relationship of baseflow to landscape processes and shoreline functions.



Dakota Creek :

Lower baseflow = less groundwater

So…. lower seasonal flows can impact shoreline habitat functions such as anadromous fish habitat

Land use can easily impact recharge and reduce low flows to levels that significantly impact aquatic habitat

Fishtrap Creek :

High baseflow = large quantities of groundwater

So…transport of nutrients, pollutants, and sediment can be a significant

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

20

Relationship of Landform, Ground Water Flow and Precipitation

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

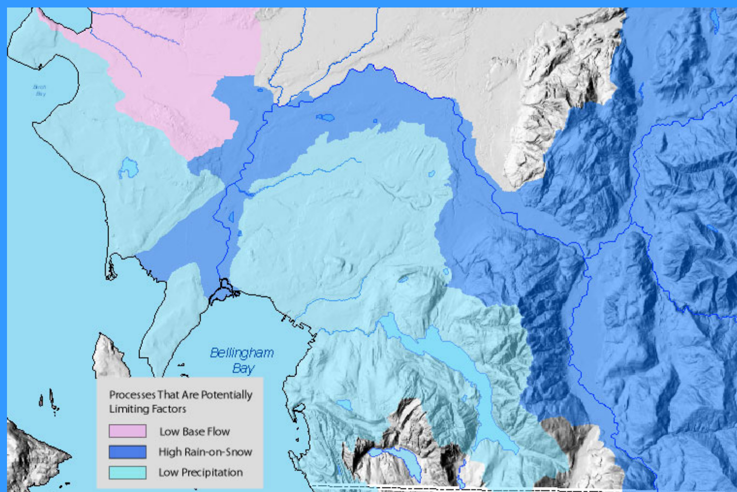
21

Relative Performance of Water Flow Indicators for Analysis Area			
WRIA Sub basin	Precipitation Assumptions: < 25" Very Low; 25-30" = Low; 30-45" = Mod; 45+" = High	Rain-on-Snow Assumptions:	Baseflow Assumptions: <60% of annual stream flow = Low 60 to 70% = Mod; >70% = High
Drayton	Low	None	Low
Birch Bay	Very Low	None	Low (BPJ – based on small basin and confining formation)
Kamm/Bertrand/ Fishtrap	Low to High	None	High
Sumas River	Moderate to High	Very Low?	?
Scott/Wiser/ Schneider	Low	None	?
Upper Nooksak Tributaries	High	Very High	Moderate
Upper Mainstem Nooksack	Mod to High	High	Mod to High
Lower Mainstem Nooksack	Low to Mod	Mod	Mod

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

22

Processes that are potentially limiting for shoreline functions



Base Info → **Landscape Processes** → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

23

Relative Performance Level of Landscape Functions			
Landform Type	**Aquifer Recharge** (includes rate & volume)	**Flood Storage** Soils, Floodplains, & Wetlands	**Water Quality Improvement**
Confining or low permeability deposit on steep slope	*Very Low*	*Very Low*	*Very Low*
Confining or low perm. deposit on terrace or low gradient slope	*Low*	*Low*	*Moderate*
Aquifer or high permeability deposit on steep slope	*Low (depends on thickness)*	*Low to Moderate (depends on thickness)*	*Low*
Aquifer or high perm deposit on terrace or low gradient slope: use aquifer thickness overlay and do relative comparison	*High for thick aquifer deposit* *Moderate for intermediate thickness* *Low to Mod for areas of thin deposits*	*High* *Moderate* *Low to Mod*	*High*
Depressions with Mineral Deposit	*Mod to High (Sandy outwash Deposit beneath mineral soils)*	*High*	*High*
Depressions with Organic Deposits	*Mod to High (Sandy outwash Deposit beneath mineral soils)*	*High*	*Very High*
Floodplains – glacially formed	*Low to Moderate*	*Very High*	*Mod to High*

Base Info → Landscape Processes → **Landscape Functions** → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

24

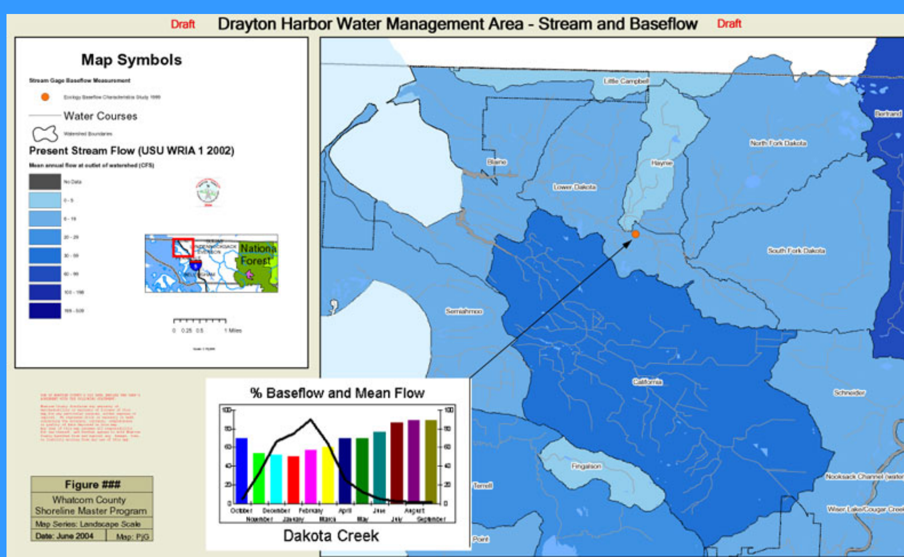
Summary of water flow processes and functions at the sub-basin scale

Drayton Harbor Example

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

25

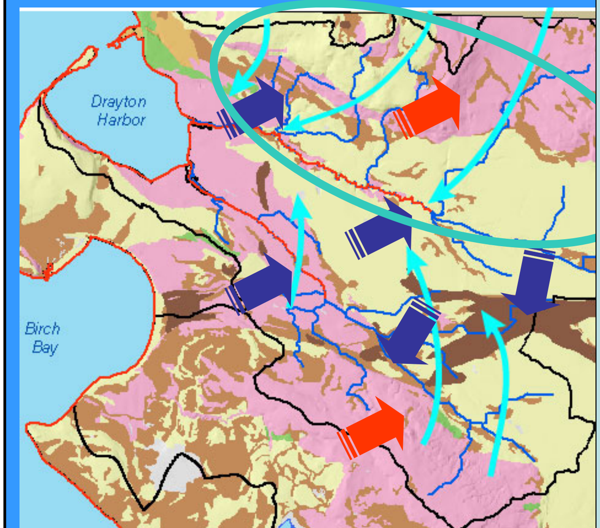
Baseflow Data



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

26

Describe water flow processes at sub basin scale



Drayton Harbor Watershed

Groundwater flow is shallow and relatively rapid on impermeable slopes.

Discharges occur at base of slopes and in depressions. Note areas of hydric soils which indicate areas of consistent discharge

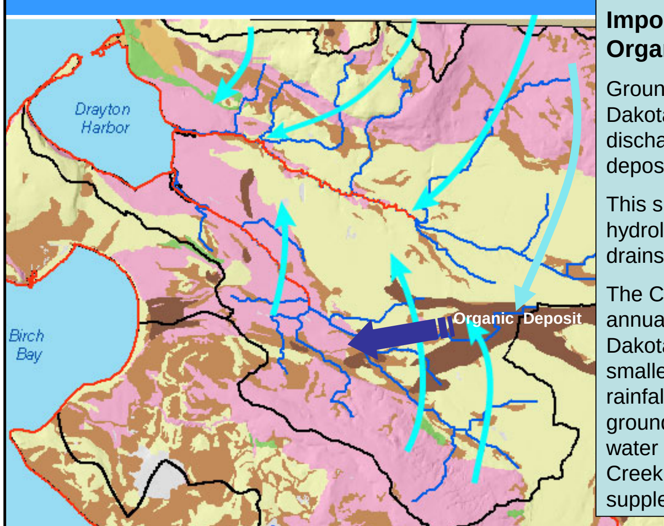
Dakota Creek - valley deposits are **permeable**, groundwater flow is deeper, pathway longer, with moderate discharge to creek but low seasonal baseflow.

California Creek - valley deposits are **impermeable**, groundwater flow is shallow with high discharge to creek. These conditions also result in low seasonal base flows.

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

27

Describe water flow processes at sub basin scale



Importance of Large Organic Deposit

Groundwater flow from the Dakota Creek watershed discharges in the large organic deposit

This surface and subsurface hydrology in the peat deposit then drains into California Creek.

The California Creek mean annual flow is higher than that for Dakota Creek despite being a smaller basin and in a lower rainfall area. It appears that groundwater and then surface water discharge from the Dakota Creek watershed may be supplementing flows.

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

28

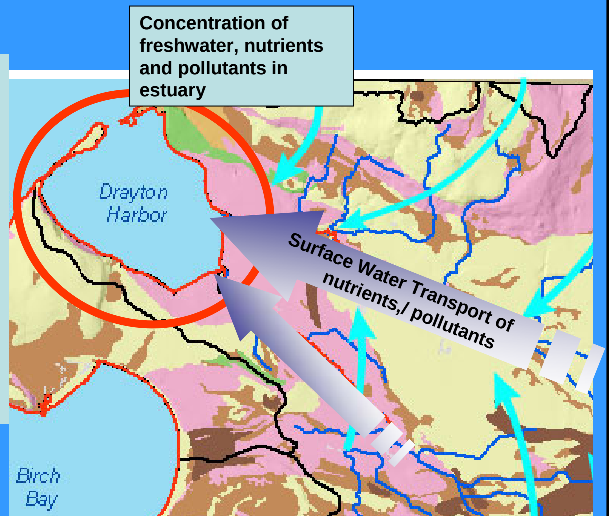
Describe water flow processes

Drayton Harbor Estuary

Estuary structure and function is driven by tidal and freshwater processes.

The estuary is within a semi-enclosed bay that **reduces tidal exchange** relative to other marine shorelines.

This can potentially **concentrate nutrients and pollutants** within the estuary.



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

29

Summarize Functions for Aquifer Recharge

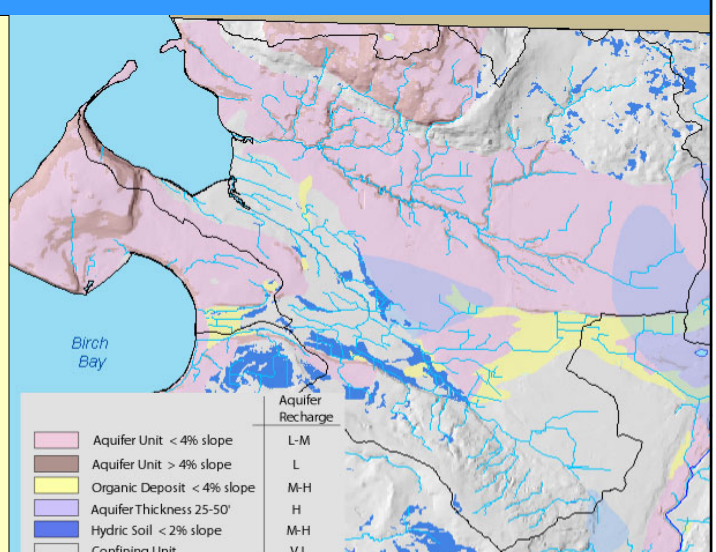
Drayton Harbor – Aquifer Recharge

Dakota Creek: Aquifer recharge function is **low** for slope areas & mod to high for depressional areas

Low to Moderate for most of valley area but **High** for two small areas in the central and eastern portion of basin.

Mod to high for depressions

California Creek. Aquifer recharge is **very low** for both slope and valley areas



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

30

Water Quality Function

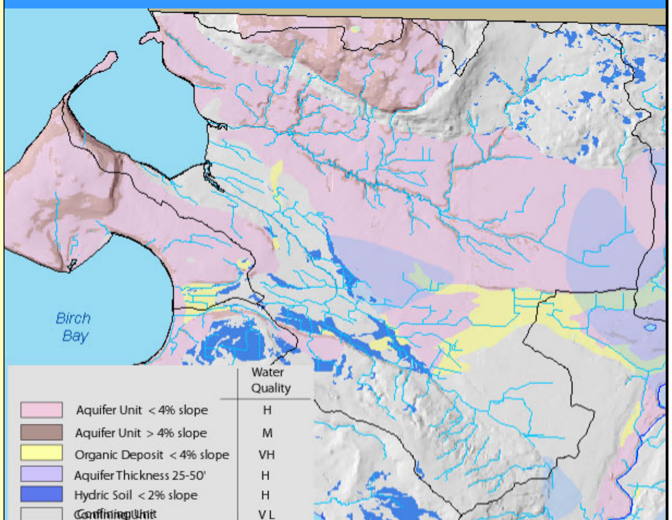
Drayton Harbor – Water Quality

Dakota Creek: Water quality function is **very low** for slope areas on a confining unit, moderate for aquifer unit on a steep slope & high for depressional areas on a confining unit.

High for aquifer unit in a valley or terrace setting.

High to Very High for depressions (includes organic deposits) in valley or terrace setting.

California Creek. **Very low** for most slope and valley areas. High for depressions and aquifer unit (in valley or terrace)



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

31

Flood Function

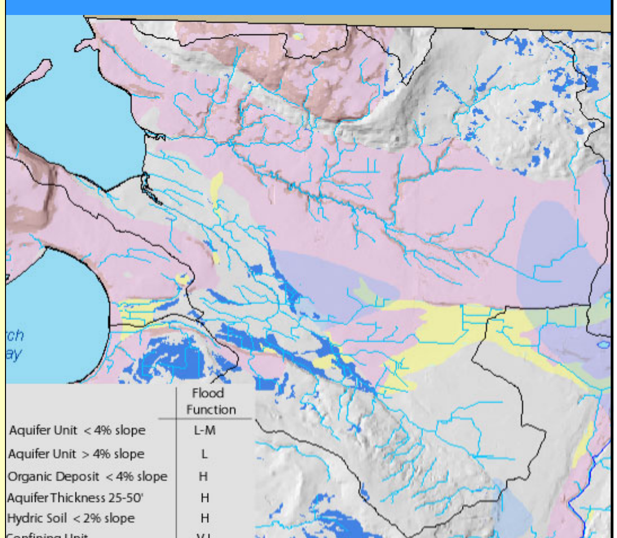
Drayton Harbor – Flood Function

Dakota Creek: For slope areas on a confining unit the Flood function is **very low**. For depressional areas on confining unit it is high.

Low to Moderate for most of valley area except for thicker deposits where it is high (eastern portion). The upper basin setting for these thicker deposits makes them especially effective in moderating downstream flooding

High for depressions especially in upper basin.

California Creek. Very low for most of the slope and valley areas (confining deposits). High for depressions and thicker aquifer units.



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

32

Describe the relationship to shoreline functions

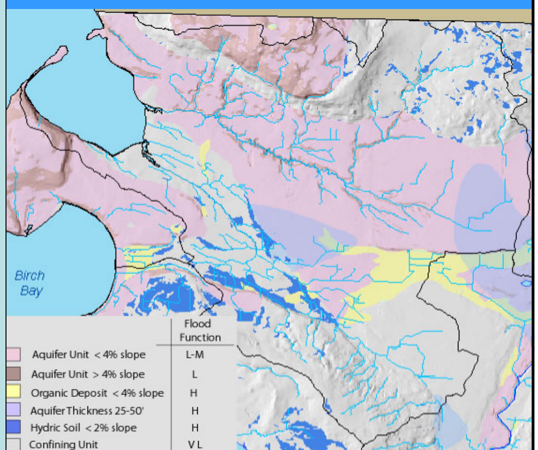
Dakota Creek - Watershed Analysis

Movement of water, nutrients & pollutants has **longer flow path** in permeable valley deposits. Most functions perform at a moderate to high level.

However, small basin, reduced aquifer capacity, and lower rainfall area results in **lower seasonal flows in shoreline areas**. Low base flows are a **limiting factor** since aquatic organisms are dependent on adequate flows in warmer months.

Estuarine habitat, especially one with reduced tidal exchange, is affected by **changes to salinity and nutrient regimes.** Stream and subsurface flows play an important role in the nature of these regimes.

Shoreline functions are dependent on maintaining adequate low flows. Alteration in processes and functions outside of shoreline could significantly impact these shoreline functions.



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

33

Describe the relationship to shoreline functions

California Creek Watershed Analysis

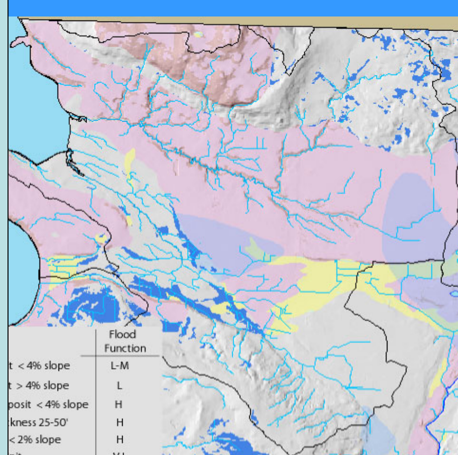
Movement of water, nutrients & pollutants has shorter **flow path** in confined slope and valley deposits. Most functions perform at a low level except for areas of depressions and more permeable deposits.

The small basin, shallow limited aquifer capacity, and lower rainfall area indicates **lower seasonal flows in shoreline areas**. Low base flows are a **limiting factor** since aquatic organisms are dependent on adequate flows in warmer months.

However, mapped groundwater flow indicates that the large organic deposit in the upper basin may be contributing additional flows to California Creek which supports higher than expected seasonal flows. These processes are important to maintaining shoreline functions.

Estuarine habitat, especially areas with reduced tidal exchange, is affected by **changes to salinity and nutrient regimes.** Stream and subsurface flows play an important role in the nature of these regimes.

Shoreline functions are dependent on maintaining adequate low flows, moderating high flows (which can change structure and functions) and nutrient/pollutant inputs. Supporting processes and functions can be easily altered in this area due to extensive confined aquifer source area. Considering these conditions, depressional areas and permeable deposits are very important to maintaining processes and functions at all scales.



asin sses → Sub-Basin Functions → Relationship to Shoreline

34

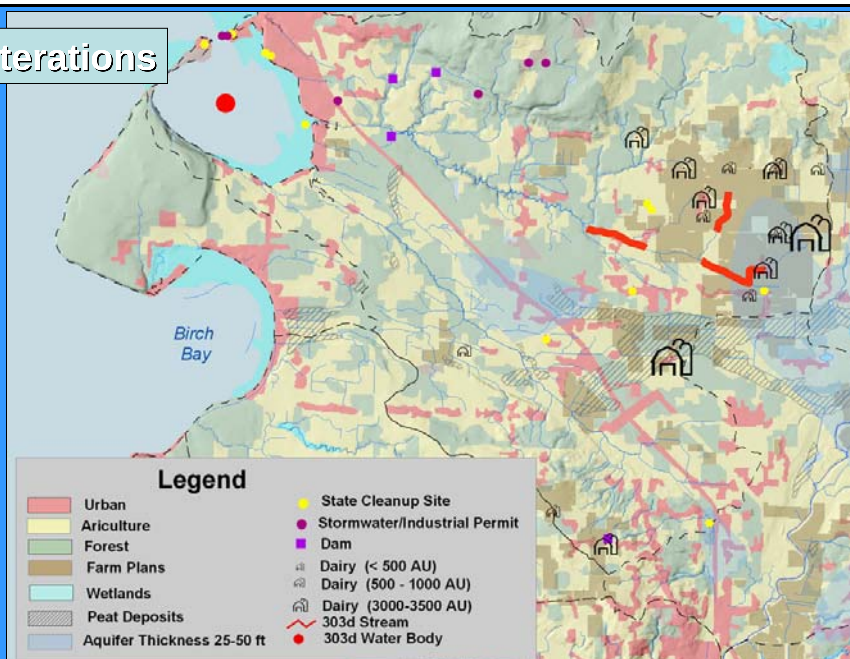
Step 2 - Identify ecological functions and ecosystem-wide processes that are healthy, altered, impacted, and missing

- Indicators of Current Condition:
  - Land cover
  - Surface water alterations (channelization)
  - Loss of wetland habitat
  - Sub-surface alterations (pumping, population density)
  - Pollutant inputs (, dairy farms, industrial uses)
  - Effect of pollutants (303 (d) listed water bodies ins.)
  - Road density
  - Stream/road crossings
- Review Existing Studies/Reports
- Consider Additional Impacts from Future Condition

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

35

Alterations



Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

36

Landscape Process & Function Analysis – Overview of Analysis Area

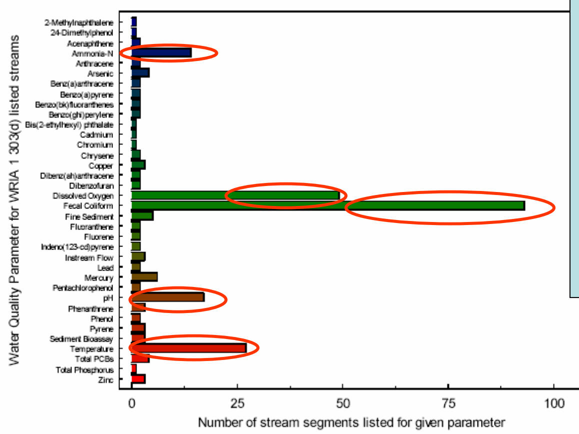


Figure 4. Number of Stream Segments Listed for a Given Parameter in WRIA1.

This graph summarizes the primary water quality problems in the study area:

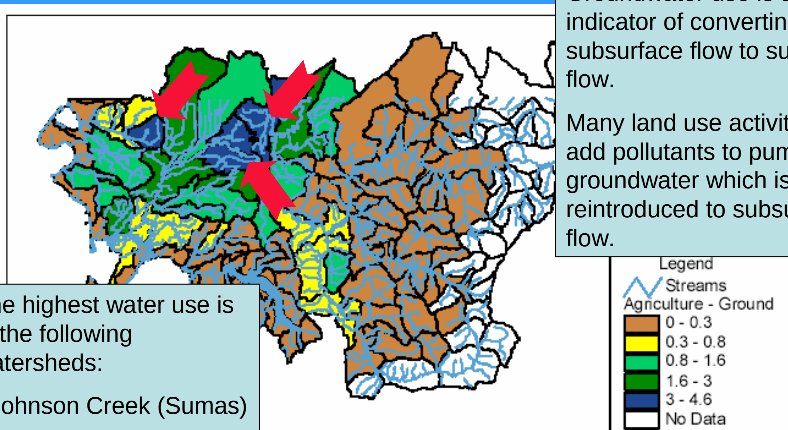
1. Fecal coliform
2. Dissolved oxygen
3. Temperature
4. pH
5. Ammonia Nitrogen

This large scale overview provides clues to the type of land uses that may be altering processes and this helps focus and identify mitigation measures. problems.

Converting Subsurface Flows – Using Water Use Layers

Groundwater use is an indicator of converting subsurface flow to surface flow.

Many land use activities will add pollutants to pumped groundwater which is then reintroduced to subsurface flow.



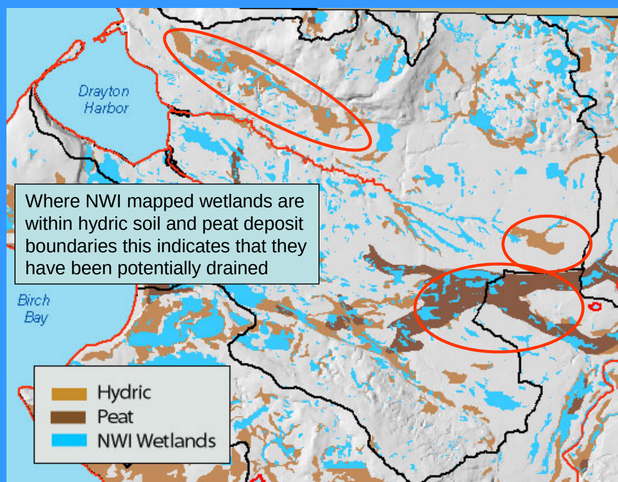
annual non-PWS agricultural ground water use in WRIA 1 (inches over drainage

The highest water use is in the following watersheds:

- Johnson Creek (Sumas)
- Kamm Slough
- Dakota Creek

38

Indicator of Surface/Subsurface Alterations – Loss of Aquatic Habitat



Where NWI mapped wetlands are within hydric soil and peat deposit boundaries this indicates that they have been potentially drained

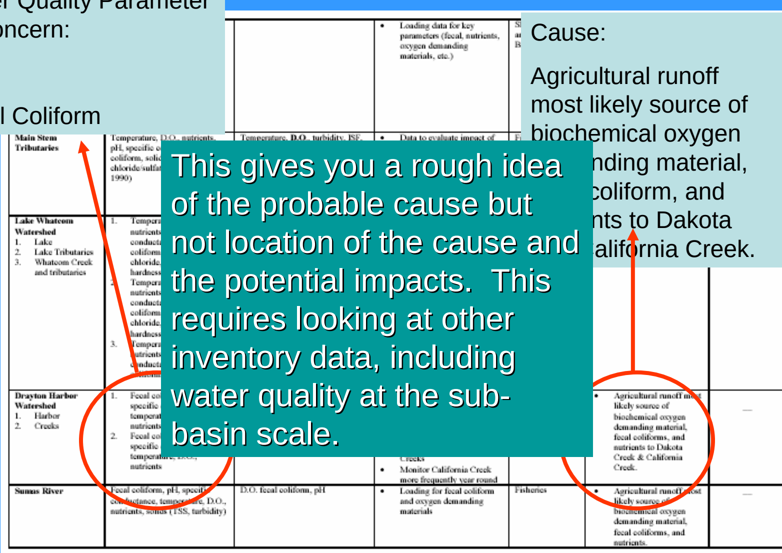
Wetlands and Riparian areas are important components in removing nutrients and toxic compounds. Wetlands that have been drained or filled no longer perform this function. Riparian areas that have been deforested and grazed/farmed perform this function at a reduced level.

Indicators of these changes include comparing hydric soil layers and NWI layers along with land use and channel layers

Water Quality Improvement Function Analysis WRIA Summary of Issues Table for Drayton Harbor

Water Quality Parameter of Concern:

Fecal Coliform

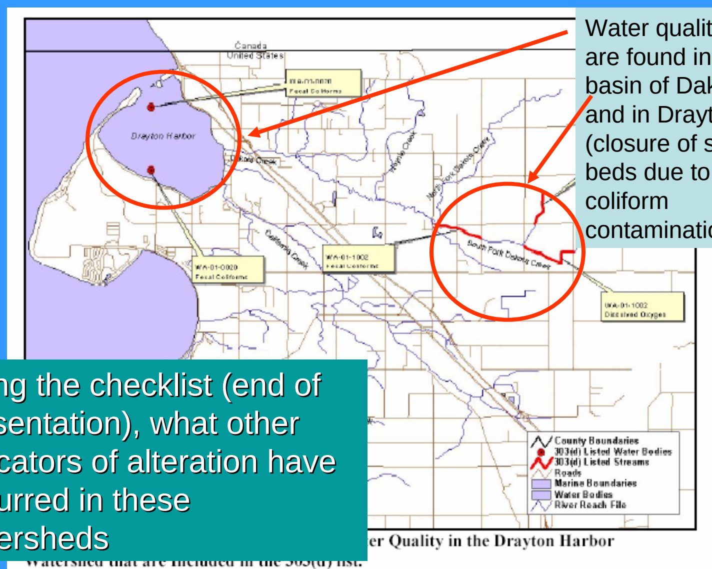


Cause:

Agricultural runoff most likely source of biochemical oxygen demanding material, fecal coliform, and nutrients to Dakota & California Creek.

This gives you a rough idea of the probable cause but not location of the cause and the potential impacts. This requires looking at other inventory data, including water quality at the sub-basin scale.

Water Quality Improvement Function Analysis – WRIA 303d listings for Drayton Harbor



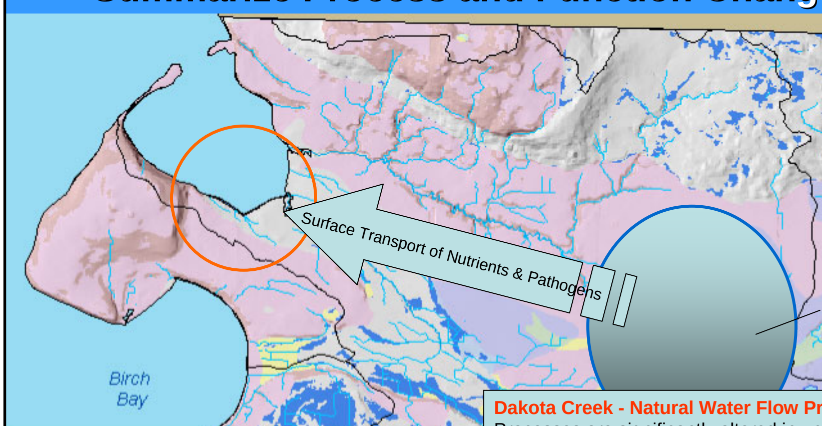
…er Quality in the Drayton Harbor

Water quality issues are found in the upper basin of Dakota Creek and in Drayton Harbor (closure of shellfish beds due to fecal coliform contamination)

Using the checklist (end of presentation), what other indicators of alteration have occurred in these watersheds

41

Summarize Process and Function Changes



Area of Significant Alteration

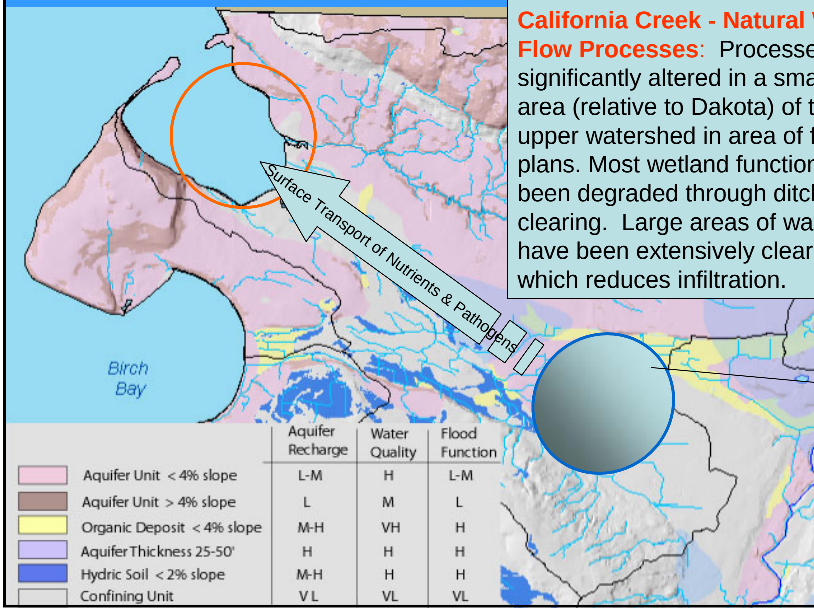
	Aquifer Recharge	Water Quality	Flood Funct
Aquifer Unit < 4% slope	L-M	H	L-M
Aquifer Unit > 4% slope	L	M	L
Organic Deposit < 4% slope	M-H	VH	H
Aquifer Thickness 25-50'	H	H	H
Hydric Soil < 2% slope	M-H	H	H
Confining Unit	VL	VL	VL

Dakota Creek - Natural Water Flow Processes: Processes are significantly altered in upper watershed of Dakota Creek in area of farm plans through a combination of field drains, ditching and tilling of fields. Results in overland flow (rainfall exceeds infiltration) and conversion of subsurface flows to surface. Extensive clearing of forest in upper basin has also increased surface flows. Most wetland functions have been altered through ditching and clearing.

42

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

Summarize Process and Function Changes



	Aquifer Recharge	Water Quality	Flood Function
Aquifer Unit < 4% slope	L-M	H	L-M
Aquifer Unit > 4% slope	L	M	L
Organic Deposit < 4% slope	M-H	VH	H
Aquifer Thickness 25-50'	H	H	H
Hydric Soil < 2% slope	M-H	H	H
Confining Unit	V L	VL	VL

California Creek - Natural Water Flow Processes: Processes are significantly altered in a smaller area (relative to Dakota) of the upper watershed in area of farm plans. Most wetland functions have been degraded through ditching and clearing. Large areas of watershed have been extensively cleared which reduces infiltration.

Area of Significant Alteration

43

Consider Additional Impacts from Future Alterations

44

Step 3 - Identify measures to protect and restore ecosystem-wide processes and ecological functions

- Identify objectives and measures for protection and restoration in the sub-basin
- Overlay current project information
- Evaluate what is not being addressed
  - Identify additional measures to restore processes

45

Identify Objectives – Dakota Sub-basin

Relevant Process & or Function – Unaltered Conditions	Existing or Potential Environmental Issue	Altered Functions and Processes	Protection & Restoration Objectives	Protection – Mechanism & Measures	Restoration Mechanism
Low summer baseflow Recharge function is low to moderate over large area of watershed	Potential: Reduced diversity of aquatic organism. Increased mortality of smolts.	Recharge function is reduced in areas of drained depressional wetlands and tilled soils	Maximize recharge	Increase infiltration: Retain forest cover Protect depressional wetlands in upper watershed Minimize impervious cover	Restore native cover and wetlands in areas of highest recharge function
Reduced tidal flushing Water quality function is high for most of the watershed except for confining units on steep slopes	Existing: Water quality impacts. Closure of Drayton harbor shellfish beds. Reports of harmful algal blooms. Cause – fecal coliform and nutrients	Water quality function is reduced in areas of drained wetlands, tilled soils, and cleared forest /shrub cover	Maximize residence time	Protect existing depressional wetlands & forest cover	Restore wetlands below areas with highest degree of alteration Restore forest/shrub cover

46

Identify Objectives – Dakota Sub-basin

Relevant Process & or Function – Unaltered Conditions	Existing or Potential Environmental Issue	Altered Functions and Processes	Protection & Restoration Objectives	Protection – Mechanism & Measures	Restoration Mechanism
Low summer baseflow Recharge function is low to moderate over large area of watershed	Potential: Reduced diversity of aquatic organism. Increased mortality of smolts.	Recharge function is reduced in areas of drained depressional wetlands and tilled soils	Maximize recharge by increasing infiltration Maintain groundwater quantities	Protect depressional wetlands in upper watershed Minimize effects of impervious cover in in areas of mod to high recharge Ensure gw pumping doesn't interrupt flow to streams.	Remove effects of drainage from wetlands in areas of highest recharge function
Reduced tidal flushing Water quality function is high for most of the watershed except for confining units	Existing: Water quality impacts. Closure of Drayton harbor shellfish beds. Reports of harmful algal blooms. Cause – fecal coliform and nutrients	Water quality function is reduced in areas of drained wetlands, tilled soils, and cleared forest /shrub cover	Maximize residence time	Protect existing depressional wetlands & forest cover	Restore wetlands below areas with highest degree of alteration Restore forest/shrub cover

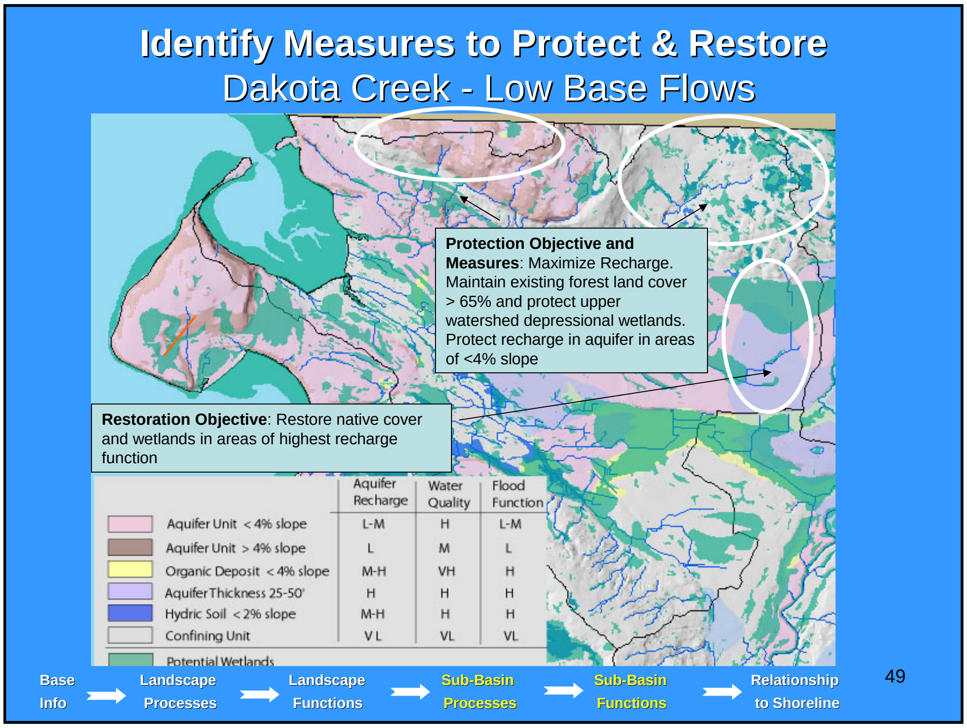
47

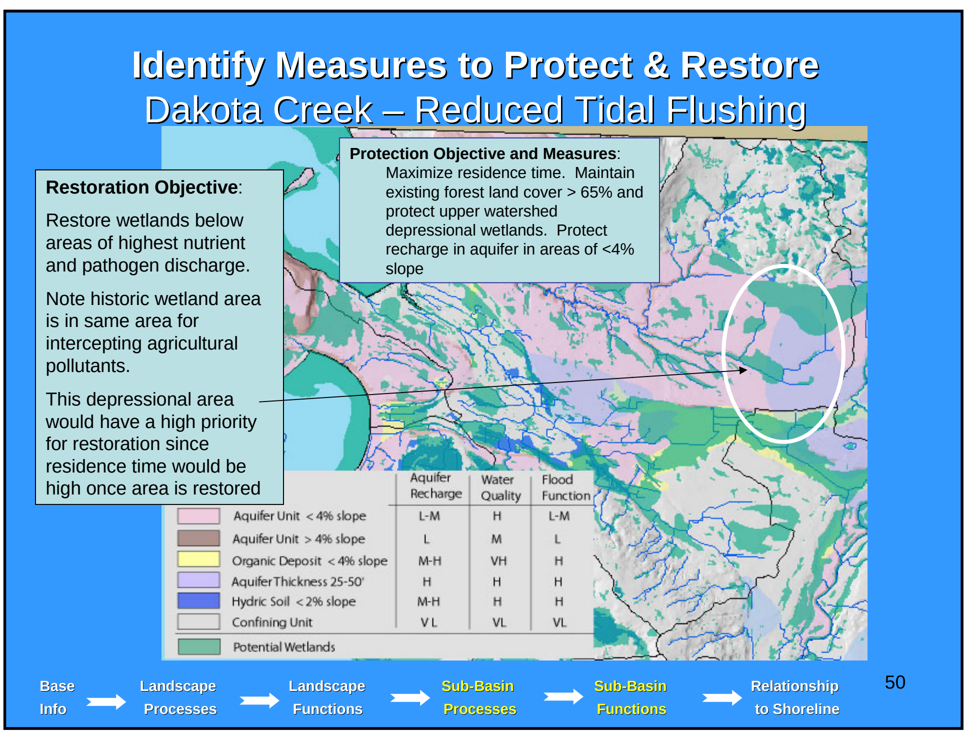
Objectives – Dakota and California Creek Sub-basin

Critical Process or Function – Unaltered Conditions	Existing or Potential Environmental Issue	Altered Functions and Processes	Protection & Restoration Objectives	Protection – Mechanism & Measures	Restoration Mechanism
Subsurface flows to and discharge in California Creek watershed	Potential: If this water flow process is altered, it could significantly affect baseflows in California Creek.	Recharge function is reduced in areas of drained depressional wetlands and tilled soils	Protect subsurface flows, including recharge of, that discharge to large organic deposit in upper California Creek	Protect large organic deposit in upper watershed of California Creek Protect lands in Dakota Creek that support this water flow Minimize impervious cover Retain native cover	Restore native cover and wetlands that support this critical water flow process.

Base Info → Landscape Processes → Landscape Functions → Sub-Basin Processes → Sub-Basin Functions → Relationship to Shoreline

48


Identify Measures to Protect & Restore
Dakota Creek - Low Base Flows
Protection Objective and Measures: Maximize Recharge. Maintain existing forest land cover > 65% and protect upper watershed depressional wetlands. Protect recharge in aquifer in areas of <4% slope
Restoration Objective: Restore native cover and wetlands in areas of highest recharge function
Aquifer Recharge
Water Quality
Flood Function
Aquifer Unit < 4% slope L-M H L-M
Aquifer Unit > 4% slope L M L
Organic Deposit < 4% slope M-H VH H
Aquifer Thickness 25-50' H H H
Hydric Soil < 2% slope M-H H H
Confining Unit VL VL VL
Potential Wetlands
Base Info
Landscape Processes
Landscape Functions
Sub-Basin Processes
Sub-Basin Functions
Relationship to Shoreline
49


Identify Measures to Protect & Restore
Dakota Creek – Reduced Tidal Flushing
Protection Objective and Measures: Maximize residence time. Maintain existing forest land cover > 65% and protect upper watershed depressional wetlands. Protect recharge in aquifer in areas of <4% slope
Restoration Objective:
Restore wetlands below areas of highest nutrient and pathogen discharge.
Note historic wetland area is in same area for intercepting agricultural pollutants.
This depressional area would have a high priority for restoration since residence time would be high once area is restored
Aquifer Recharge
Water Quality
Flood Function
Aquifer Unit < 4% slope L-M H L-M
Aquifer Unit > 4% slope L M L
Organic Deposit < 4% slope M-H VH H
Aquifer Thickness 25-50' H H H
Hydric Soil < 2% slope M-H H H
Confining Unit VL VL VL
Potential Wetlands
Base Info
Landscape Processes
Landscape Functions
Sub-Basin Processes
Sub-Basin Functions
Relationship to Shoreline
50

Identify Objectives – California Creek Watershed (cont.)

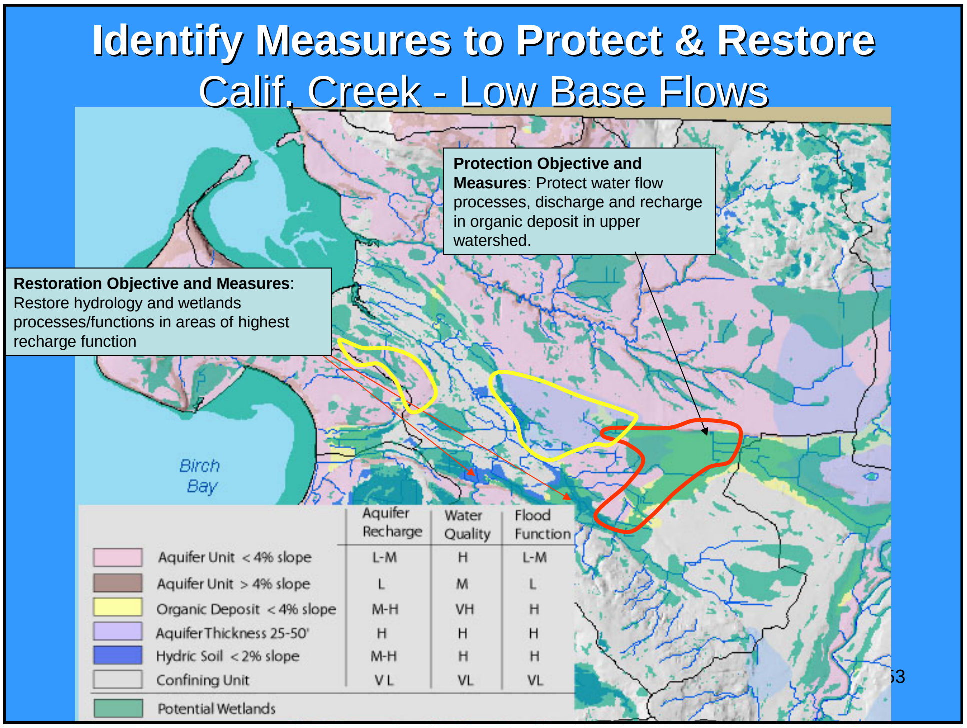
Relevant Process & or Function	Existing or Potential Environmental Issue	Alteration to Process	Threat or Cause of Alteration	Protection & Restoration Objectives	Protection – Mechanism & Measures	Restoration Mechanism
Peak Flows	Potential: Reduced diversity of aquatic organisms in fresh water areas, (structural complexity reduced) and increased transport of nutrients & pollutants to estuary.	Increased runoff	Tilling of soils in confining layer Impervious surfaces - development	Maximize infiltration in areas of confining formation	Retain existing forest cover Minimize effects of impervious cover in confining areas.	Increase native forest cover in areas of low performance recharge function
Flood Storage (potential)		Loss of storage volume	Drainage of depressional wetlands	Maximize residence time? (really maximize or restore storage capacity/ volum)	Protect depressional wetlands in areas of confining formation (low performance of flood function)	Restore wetlands in areas of confining formation.

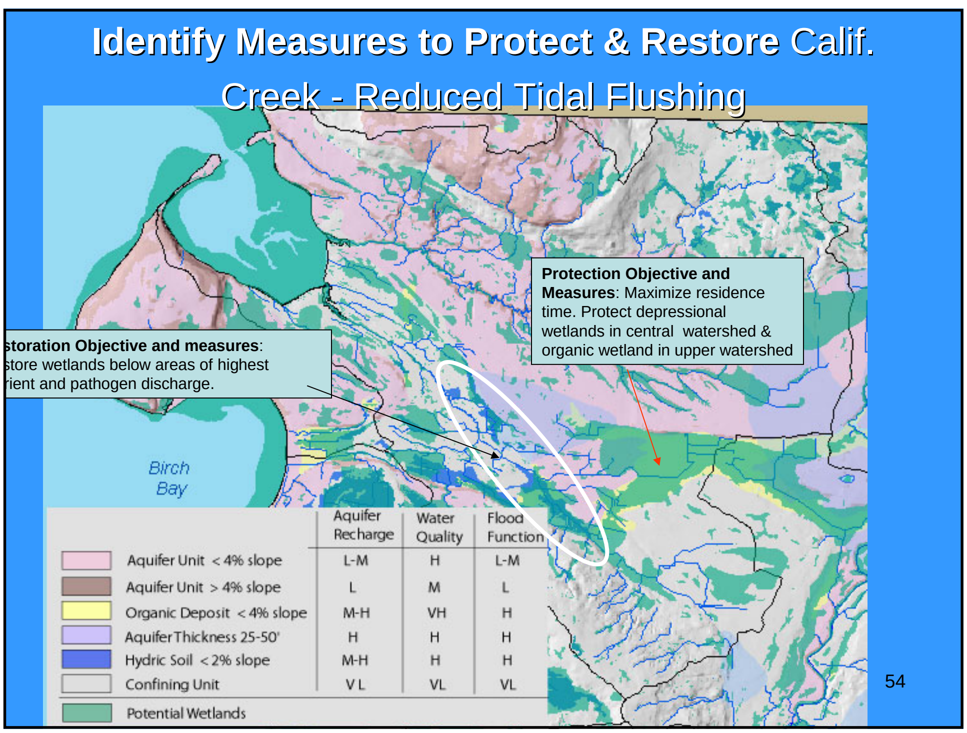
51

Identify Objectives – California Creek Watershed (cont.)

Critical Process or Function – Unaltered Conditions	Existing or Potential Environmental Issue	Altered Functions and Processes	Protection & Restoration Objectives	Protection – Mechanism & Measures	Restoration Mechanism
Discharge in large organic deposit and surface and subsurface flows from deposit into California Creek	**Potential: If this water flow process is altered, it could significantly affect baseflows in California Creek.**	**Organic deposit has been channelized converting subsurface flows to surface and reducing hydrology in large portions of deposit and performance of wetland functions**	**Protect subsurface flows, including movement of flows through deposit and discharge to California Creek.** **Restore hydrology to drained portions of organic deposit**	**Protect large organic deposit in upper watershed of California Creek Protect lands in Dakota Creek that support this water flow** **Minimize impervious cove.r Retain native cover**	**Restore hydrology to drained portions of organic deposit by reducing area drained by ditches and field tiles.**

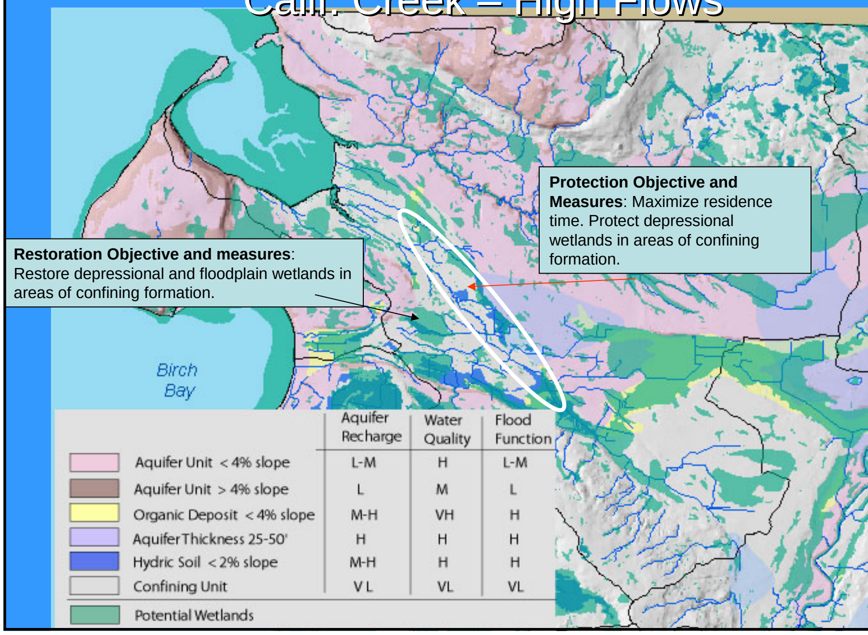
52


Identify Measures to Protect & Restore
Calif. Creek - Low Base Flows
Protection Objective and Measures: Protect water flow processes, discharge and recharge in organic deposit in upper watershed.
Restoration Objective and Measures: Restore hydrology and wetlands processes/functions in areas of highest recharge function
Birch Bay
Aquifer Recharge
Water Quality
Flood Function
Aquifer Unit < 4% slope L-M H L-M
Aquifer Unit > 4% slope L M L
Organic Deposit < 4% slope M-H VH H
Aquifer Thickness 25-50' H H H
Hydric Soil < 2% slope M-H H H
Confining Unit V L VL VL
Potential Wetlands


Identify Measures to Protect & Restore Calif. Creek - Reduced Tidal Flushing
Protection Objective and Measures: Maximize residence time. Protect depressional wetlands in central watershed & organic wetland in upper watershed
storation Objective and measures: store wetlands below areas of highest rient and pathogen discharge.
Birch Bay
Aquifer Recharge
Water Quality
Flood Function
Aquifer Unit < 4% slope L-M H L-M
Aquifer Unit > 4% slope L M L
Organic Deposit < 4% slope M-H VH H
Aquifer Thickness 25-50' H H H
Hydric Soil < 2% slope M-H H H
Confining Unit V L VL VL
Potential Wetlands
54

Identify Measures to Protect & Restore

Calif. Creek – High Flows



55

Identify Existing Restoration Projects

56

Review Existing Restoration Plans and Projects

- Determine if they meet listed objectives & which ones
- Determine which objectives still need to be addressed
- Identify measures to address those objectives

57

High Priority Restoration Area for Dakota Creek - Outside of Shoreline Jurisdiction – Intersection of Sunrise Road and Dakota Creek – Site identified by Multi-Purpose Storage Grant project

Figure 16 . Potential wetland restoration area for Dakota Creek. Downstream of this restoration area is primarily forested and therefore with less restoration potential.

58